

AGRICULTURAL METEOROLOGY.

J. WARREN SMITH, Meteorologist.

[Weather Bureau, Washington, D. C., June 1, 1920.]

Definition.—Agricultural Meteorology in its broadest sense is "Meteorology in its Relation to Agriculture."

Historical.—The effect of the weather upon crop growth was early recognized, and in 1806 the Hon. Simeon De Witt, of Albany, N. Y., read a memoir on "Climate in its Relation to Agriculture" before the American Agricultural Society in New York City.

On April 29, 1817, Josiah Meigs, Commissioner of the General Land Office, issued a circular soliciting meteorological records and phenological observations by the registrars of the respective land offices.

In 1819 the Surgeon General of the Army established a system of meteorological observations at the Army posts.

In 1825 the regents of the University of the State of New York directed that meteorological observations be made at each of the academies under their supervision.

In 1837 the Franklin Institute and the State of Pennsylvania began cooperation in the establishment of meteorological stations in each county in the State. The first special appropriation of public money for the collection of weather data in this country was made when the legislature of Pennsylvania granted \$4,000 to the Franklin Institute.

The first official action of the United States in the study of weather conditions was made by Congress in 1842 in the appointment of Prof. J. P. Espy as meteorologist in the United States Government.

The present United States Weather Bureau was inaugurated by an act of Congress on February 9, 1870, authorizing the Secretary of War to organize a meteorological service throughout the United States. In 1872 the appropriation bill, in addition to the money for the work of the Signal Corps for the prediction of storms on the seacoast, provided for "such additional stations, reports, and signals as may be found necessary for the benefit of agricultural and commercial interests."

The Iowa State Weather Service was established in 1875, the Nebraska Service in 1878, Missouri State Weather Service in 1877, and the Ohio Meteorological Bureau in 1882. By 1891 a special weather and crop service was in operation in nearly every State.

The publication of Weather and Crop Bulletins was begun in May, 1887.

On July 1, 1891, all the meteorological work of the Signal Service was transferred to the Department of Agriculture and the present United States Weather Bureau was put into operation. Since this transfer, the work of the Weather Bureau in its relation to Agriculture has developed steadily. Special services have been established for the direct benefit of agriculture, such as the Corn and Wheat, Cotton, Sugar and Rice, Cattle, Tobacco, and Fruit Region Services. Special forecast and warning services have been inaugurated for tobacco, fruit, and truck growers; alfalfa and rice harvesting; fruit spraying, alfalfa seed harvest, and sheep shearing and lambing interests.

The present Division of Agricultural Meteorology was established as a new division in the Weather Bureau on February 23, 1916, and the work of the Bureau relating particularly to agriculture was placed under its supervision. The National Weather and Crop Bulletin has been developed to show the weather from week to week, and its effect upon the growing crops, and studies are

being made to find the most critical periods of growth of the various crops and the weather most affecting them. Detailed temperature and moisture surveys are being carried on in citrus and deciduous orchards to determine the distribution of damaging weather factors, the effect of orchard heating on the temperature, and the part that radiation plays in temperature variations and fruit protection. Valuable studies in the forecasting of minimum temperatures have been published and equations evaluated from the knowledge of the moisture in the atmosphere in the afternoon and its relation to the temperature variations during the following night.

The future.—The writer believes that there are certain well defined and determinable periods, usually comparatively short, in the growth of most crops when the weather has a particular, favorable or unfavorable, effect upon the yield. Also that there are three definite methods for ascertaining the limits of these periods and the weather factor or factors having the greatest effect.

One of these methods is properly called the laboratory method wherein all factors affecting growth can be controlled. This problem is one that many ecologists and plant physiologists are at work on, and valuable data have been evolved. Livingston, Shreve, Briggs, Shantz, McDougal, Lehenbauer, and others have contributed to these studies.

The second method calls for a long series of field observations with careful and detailed meteorological and growth records. Many experiment station and other officials are already at work in this direction and are producing valuable results. One of the most important studies recently published is entitled "Effect of the Relative Length of Day and Night and Other Factors of the Environment on Growth and Reproduction in Plants," a contribution from the Bureau of Plant Industry, United States Department of Agriculture, by W. W. Garner and H. A. Allard, and is found in the *Journal of Agricultural Research* for March 1, 1920.

Another plan based upon phenological records and periodical phenomena in general has received attention in Europe for many years.

Within recent years this branch of science has been systematized for direct application to agricultural problems by Dr. A. D. Hopkins, of the Bureau of Entomology, United States Department of Agriculture, who has determined that the variation in dates of periodical events and the altitude of geographical distribution with variations in geographical position is in accordance with natural law, which he has designated and defined as the Bioclimatic Law.¹ According to this law the rate of variation in the dates and periods of natural phenomena and farm practice with variations in latitude, longitude, and altitude is governed in a sufficiently definite manner to form a reliable basis for predicting the dates and periods of seasonal events for any place in the United States. The general reliability of this method of prediction has been demonstrated in the case of seeding and harvest time for winter wheat, as fully described in the publication referred to.

Plans were started early in 1916 for the inauguration of systematic observations of this character at agricultural experiment stations in different parts of the United States. An interbureau committee was appointed in the

¹ Periodical events and natural law as guides to agricultural research and practice. *MO. WEATHER REV. SUPPLEMENT* No. 9, May 1, 1918, pp. 5-42.

Department of Agriculture to consider methods, records, etc. This committee considered the whole matter carefully and, after interruption by the war, finally recommended the establishment of 12 regional agricultural meteorological stations in the principal corn, cotton, wheat (winter and spring), and potato districts.

The fact was recognized that similar stations were established in Russia in 1896, where, in 1912, complete records were being made at 81 different points. The Canadian meteorological service recognized the great importance of such stations and had, in 1915, located them at 14 different experiment farms in different sections of the country.

The Royal Meteorological Society in England has collected systematic phenological data since 1875, and similar work has been done in nearly all European countries. A division of agricultural meteorology was established in Brazil in 1910, in Germany in 1911, and in France in 1912.

It is believed that the United States, with its splendid Weather Bureau organization and well-established chain of Experiment Stations, should not be behind these other countries in putting this needed study of weather and crops on a real scientific basis with systematic observations and records. Funds were requested for this purpose in the last estimate, but the appropriation was not allowed by the congressional committees. It is hoped that better success will be had with the next Congress.

The third method of ascertaining the critical period of growth is by correlating past records of weather and crop yields. Meteorological and crop yield data are available in some States for a period of 50 or more years and a number of studies have been published. Some of the most important ones appear in the list given below and a number of men have similar studies in hand. The field is large and much material is available. The writer is satisfied that the problem is one for higher mathematics and that it is worthy the attention of the best trained men in the country.

The American Meteorological Society can well encourage studies that will have such a far-reaching effect on agriculture as these promise.

BIBLIOGRAPHY ON AGRICULTURAL METEOROLOGY.

- Blair, T. A.**
Rainfall and spring wheat. *Mo. WEA. REV.*, Oct., 1913.
Temperature and spring wheat in the Dakotas. *Mo. WEA. REV.*, Jan., 1915.
Partial correlations applied to Dakota data on weather and wheat yield. *Mo. WEA. REV.*, Feb., 1918.
A statistical study of weather factors affecting yield of winter wheat in Ohio. *Mo. WEA. REV.*, Dec., 1919.
- Brounoff, P.**
Crops and the weather. *Bul. Foreign Agric. Intelligence*, Ottawa, Canada. Dept. of Agric., Vol. VI, 5.
- Kincer, B. J.**
Relation of weather to the amount of cotton ginned during certain periods. *Mo. WEA. REV.*, Jan., 1917.
A correlation of weather conditions and the production of cotton in Texas. *Mo. WEA. REV.*, Feb., 1915.
- Moore, H. L.**
Forecasting the yield and price of cotton. Macmillan Co., N. Y.
- O'Connor, A. J.**
Relation of weather to yield of winter wheat in Manitoba. *Mo. Bul. of Agric. Statistics*, Ottawa, Canada, Apr., 1918.
- Root, C. J.**
Relation of snowfall to yield of winter wheat. *Mo. WEA. REV.*, Oct., 1919.
- Seeley, D. A.**
The relation between temperature and crops. Reprint, 19th Report Michigan Acad. of Sciences, 1917.
- Smith, J. Warren.**
Effect of weather upon the yield of corn. *Mo. WEA. REV.*, Feb., 1914.
Effect of weather upon the yield of potatoes. *Mo. WEA. REV.*, May, 1915.
Effect of snow on winter wheat in Ohio. *Mo. WEA. REV.*, Oct., 1919.
- Other recent studies bearing on the general subject of the effect of weather and climate upon vegetation and farm management are indicated in the following list:
- MONTHLY WEATHER REVIEW.**
- Alter, J. Cecil.**
Alfalfa seed growing and the weather in Utah. (May, 1919.)
- Hopkins, A. D.**
Periodical events and natural law as guides to agricultural research and practices. (*The Bioclimatic Law*.) (Supplement 9.)
- Kincer, J. B.**
Daytime and nighttime precipitation and their economic significance. (Nov., 1916.)
Relation between vegetative and frostless periods. (Feb., 1919.)
The seasonal distribution of precipitation and its frequency and intensity in the United States. (Sept., 1919.)
Sunshine in the United States. (Jan., 1920.)
Temperature influence on planting and harvesting dates. (May, 1919.)
- Reed, W. G., and Tolley, H. R.**
Weather as a business risk in farming. (June, 1916.)
- Stine, O. C., and Baker, O. E.**
Climate of the cotton belt. (July, 1919.)
- Smith, J. Warren.**
Cultivation does not increase the rainfall. (Dec., 1919.)
Predicting minimum temperatures from hygrometric data. (Supplement 16.)
- Department of Agriculture Yearbook.*
- Baker, O. E., Brooks, C. F., Hainsworth, R. G.**
Graphic summary of seasonal work on farm crops. (Separate 758, 1917.)
- Smith, Middleton, Baker, O. E., Hainsworth, R. G.**
Graphic summary of American agriculture. (Separate 681, 1915.)
- Finch, V. C., Baker, O. E., Hainsworth, R. G.**
Graphic summary of world agriculture. (Separate 713, 1916.)
- Department of Agriculture Publications.*
- Finch, V. C., and Baker, O. E.**
Geography of the world's agriculture. 1917.
- Journal of Agricultural Research.* Dept. of Agric., Washington, D. C.
- Dorsey, M. J.**
Relation of weather to fruitfulness in the plum. (Vol. XVII, No. 3.) [Abstr., p. 285, below.]
- Agricultural Experiment Station Bulletins.*
- Alter, J. Cecil.**
Alfalfa seed growing and the weather. (Bul. 171, Logan, Utah.)
- Baker, O. E., and Whitson, A. R.**
Climate of Wisconsin and its relation to agriculture. (Bul. 223, July, 1912.)
- Spafford, R. R.**
Effect of climate and soil upon agriculture. (Univ. Studies, Lincoln, Nebr., Feb., 1916.)
- Farmers' Bulletins.* Dept. of Agric., Wash., D. C.
- Thompson, H. C. T.**
Home gardening in the south. (No. 934, 1918.)
- Young, Floyd D.**
Frost and protection from damage by it. (No. 1096, 1920.)
- Maryland Weather Service.*
- McLean, Forman T.**
Preliminary study of climatic conditions in Maryland as related to plant growth. (Special Pbn. Md. Wea. Serv., Vol. IV, Pt. 1A. Also Phys. Res. No. 2, 1917.)
- McLean, Forman T.**
Relation of climate to plant growth in Maryland. (Md. Wea. Rev., Feb., 1915.)
- American Geographical Society, New York City.*
- Arctowski, H.**
Corn crop in the United States. (Vol. XLIV, Oct., 1912.)